DOCUMENT RESUME

ED 178 360 SE 029 349

AUTHOR Cohen, Martin P.; Fliess, Robert F.
TITLE Minicalculators and Instructional Impact: A Teacher Survey.
INSTITUTION Pittsburgh Univ., Pa. School of Education.
PUB DATE [79]
NOTE 37p.; Not available in hard copy due to marginal legibility of original document

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Administrative Policy; Calculation; *Educational Research; Mathematics Curriculum; *Mathematics Instruction; Secondary Education; *Secondary School Mathematics; *Surveys; *Teacher Attitudes; *Teacher Behavior; Teaching Techniques
IDENTIFIERS *Calculators

ABSTRACT

A survey was conducted to determine: (1) secondary school mathematics teachers' attitudes toward calculator usage in mathematics classes; (2) teacher practices in allowing and/or encouraging the use of calculators; and (3) teachers' perceptions of their schools' policies regarding calculators in the mathematics classroom. The results indicated that teachers generally favor calculator usage, but also tend to believe that calculators should not be used as a substitute for developing computational skills. Teachers were more likely to allow and/or encourage the use of calculators in higher level mathematics courses. The school districts involved in this study had not developed clear-cut policies on calculators in the classroom. (MK)

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Minicalculators and Instructional Impact: A Teacher Survey*

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*This study was supported by Research Grant # 01-03127 from the School of Education, University of Pittsburgh, Pittsburgh, Pennsylvania

SE 029 349

TABLE OF CONTENTS

INTRODUCTION——1

Problems, Purposes, and Significance——1

Definitions——2

RELATED LITERATURE AND ANALYSIS——2

DESIGN OF STUDY——5

Restatement of the Problem——5

Procedure——5

Description of the Data-Gathering Instrument——6

Reliability of Questionnaire——7

Statistical Techniques——7

RESULTS——8

Descriptive Data——8

Personal Use and Classroom Knowledge——8

Attitudes Toward the Use of Calculators in the Mathematics Classroom——9

Attitudes Toward Teacher Training and Materials——10

Policies——10

Survey of Teacher Practices——11

Correlations of Attitudes, Practices, and Descriptive Data——13

CONCLUSIONS——13

RECOMMENDATIONS——15

REFERENCE NOTES——17

REFERENCES——18

APPENDIX A: COVER LETTER AND QUESTIONNAIRE——i

APPENDIX B: TABLES——v

APPENDIX C: COMMENTS——xiii

INTRODUCTION

Problems, Purposes, and Significance

In recent years the development and mass production of hand-held electronic calculators has made calculating machines much more accessible to the general public. With the widespread production and sale of these small, inexpensive calculating machines a controversy has arisen in mathematics education: When and how, if at all, should calculators be used in the classroom?

The purpose of this report is threefold: to survey attitudes of secondary school mathematics teachers concerning the use of calculators in math classes; to survey teacher practices of allowing and/or encouraging students to use calculators in their math classes; and to survey teachers' perceptions of their schools' policies regarding the use of calculators in math instruction.

With the technological advances being made in the production of small, inexpensive calculators, and the increasing use of electronic devices as teaching aids in instructional curricula, it is not unlikely that schools and school systems will begin to incorporate electronic calculators into their mathematics curricula in the next few years. It is generally assumed that teachers' attitudes toward the teaching methods and materials they are using affects the success of their teaching efforts. Therefore, it is important to determine how teachers feel about the use of electronic calculators in their classrooms. An administrative decision to include the use of calculators in math curricula could seriously undermine the effectiveness of a teacher who is vehemently against the use of calculators in the classroom, while restrictions on the use of calculators could undermine the efforts of the teacher who sees the use of calculators as being highly beneficial.

The second purpose of this study is to survey current teacher proactices of allowing and/or encouraging students to use calculators in secondary math classes in a large, metropolitan area. According to Suydam (1978), ". . .no data have thus far been cited about the extent to which calculators are being used in schools."[1]

The third purpose of this study is to assess teachers' perceptions of their schools' policies and attitudes toward the use of calculators in math classes. If a teacher believes that his or her school or school system favors the use of calculators, he or she may be using calculators in the classroom regardless of personal attitudes, merely to comply with what are seen to be administrative policies. School policies may even affect the personal attitudes of individual teachers regarding the use of calculators in the classroom. Teachers' attitudes also can have a great deal of influence upon administrative decisions on both the school and school district levels. Therefore, teachers' perceptions of current policies regarding the use of calculators in the classroom could be an indication of official administrative decisions to be made in the future regarding this controversy.

Definitions

For the purposes of this report, "calculator" will be defined as any calculating machine which can perform at least the four basic operations, but cannot be programmed by the operator. This includes old style adding machines (with four functions), but not computers. This definition will be used for this report, even though it is the advent of the small, hand-held calculator (and not the adding machine) which has brought about the educational controversy regarding the use of such computational aids in the classroom.

The terms "secondary school" and "secondary classes" refer to grades seven through twelve; "teacher" generally refers to the secondary school mathematics teacher. The mathematics classes with which this study is concerned are secondary school classes dealing with the teaching and learning of arithmetic and/or mathematics, and not those dealing with computer science or business mathematics.

RELATED LITERATURE AND ANALYSIS

The literature concerning the use of calculators in mathematics education has, as is expected, grown considerably since the introduction of inexpensive hand-held calculators. Much of the literature is concerned with ways in which calculators can be used in mathematics instruction. Frank Van Atta discusses how calculators can be used with lessons involving exponents and the Pythagorean theorem.[2] Eli Maor encourages

teachers to let students use calculators to discover patterns and verify mathematical statements.[3]

In recent years there has been an increasing amount of research concerning the effects of the use of calculators in mathematics instruction upon student outcomes. Most of the research, including the work of Advani (1972), Cech (1960), Ellis (1969), and Longstaff (1968), indicates that the use of calculators does not have a significant effect upon student achievement in mathematics. However, it is interesting to note that none of the research shows negative effects, as some claims have been made that the use of calculators interferes with the learning of mathematics. Beck (1960), in studying fourth, fifth, and sixth graders, found an increase in the understanding of basic skills when calculators were used in math instruction, particularly in the understanding of place-value concepts.[4] Keogh's and Burke's (1969) study of eleventh and twelfth graders showed that those students who used calculators during instruction achieved significantly higher scores on a standardized mathematics test than those students who did not use calculators during instruction.[5]

Studies using fifth through tenth grade students that were designed to assess changes in student attitudes toward and interest in mathematics were for the most part split in their results. Cech (1960), Ellis (1969), and Longstaff (1968) found no differences in student attitudes toward mathematics when comparing groups in which calculators were and were not included in instruction. Advani (1972), Beck (1960), and Broussard (1969) found that students who used calculators in instruction had better attitudes toward math than those in groups that did not use calculators. They also found that those students who had used calculators in their math classes were more likely to take a personal interest in mathematics and to continue to take math courses even though the courses were not required.

Some of the research in the use of calculators in the classroom also deals with the effect upon student behavior. Advani (1972), Beck (1960), and Longstaff (1968) found that student behavior in the classroom was less disruptive when calculators were used as instructional aids.

Longstaff's study included data regarding the effects of the use of calculators as instructional aids upon teacher enthusiasm. He found

That teacher enthusiasm increased the most when calculators ere used in classes with students with the lowest average I.Q.'s. He also found that teacher enthusiasm for the use of calculators was unrelated to student performance.[6]

The literature concerning the use of calculators in mathematics instruction includes quite a few opinion pieces. The authors argue for or against the use of calculators in the classroom, at times citing research and at times offering suggested guidelines for their use. Morris Kline (1974) fears that the use of calculators in the classroom will cause the teaching of computation to be neglected, and states that this should not be.[7] Hawthorne (1973) believes that calculators will eventually eliminate the need to use arithmetic without a calculating device, but feels that it will still be important to understand arithmetic. Therefore, he believes that calculators do not belong in the classroom.[8] As stated previously, Van Atta suggested a use of calculators regarding the Pythagorean theorem. He claims: "A student can probably find the relationship without a calculator, but he is more apt to try many different relationships and work out more interesting problems if he is aided by a calculator."[9]

Marilyn N. Suydam (1978) discussed the advantages and disadvantages of using calculators in the classroom. Her reasons for using calculators are as follows: calculators aid in computation; they facilitate understanding and concept development; they lessen the need for memorization; they help in problem solving; they motivate; they aid in exploring, understanding, and learning algorithmic processes; they encourage discovery, exploration, and creativity; and their existence cannot be ignored by educators. The disadvantages of using calculators are as follows: they could be used as substitutes for developing computational skills; they are not available to all students; they give a false impression of what mathematics is (computation, instead of process); they are faddish, and could be used without planning or research; and they lead to maintenance and security problems.[10]

Besides summarizing the pros and cons of calculator use in the classroom, Suydam gives a "state-of-the-art" review on calculators in education. She points out that at this time there is no real data concerning "the extent to which calculators are being used in the schools. . . only the results of a few relatively small-scale surveys, plus perceptions of those who work with and observe school programs."[11]

The most significant of the "small-scale surveys" was a survey done in the Shawnee Mission (Kansas) Public Schools in 1975 and 1977. This survey determined that the number of students owning or having access to calculators increased significantly between 1975 and 1977.[12] This survey also indicated that teachers' opinions concerning the use of calculators changed from 1975 to 1977; "Teachers were asked, 'Should calculators be used in schools by students?' In 1975, 65.2% said 'yes'; 1977, 71.6% said 'yes'."[13]

Suydam also summarizes some of the main uses of calculators in secondary mathematics education, while pointing out that information concerning types of uses is limited. The four uses she cites are: calculation, recreation and games, exploration, and use of calculator-specific materials.[14]

DESIGN OF STUDY

Restatement of the Problem

In completion of this survey, information was gathered about teachers' attitudes and practices involving the use of calculators in mathematics classes for grades nine through twelve. Information was also obtained regarding teachers' perceptions of their schools' policies concerning the use of calculators in math classes.

Among the questions studied in surveying attitudes and practices of using calculators in math classes are:

1. What are good reasons for using calculators in the math classroom? (e.g.: to aid in computation, to lessen memorization, to help in problem solving, to improve behavior, availability, understanding algorithmic processes).
2. What are reasons for not using calculators in the math classroom? (e.g.: they become a substitute for computational skills, lack of availability, faddishness, maintenance and security problems, they give a false impression of mathematics).
3. When, if at all, should students be allowed to use calculators in the math classroom? (e.g.: for homework, in class, for tests).
4. Should the use of calculators be taught to the students? If so, for what courses?

Procedure

This survey included all public high schools in Allegheny County. A "high school" was defined as ninth through twelfth grades, although

several of the schools surveyed also included seventh and eighth grades. In such a case, all the questionnaires that were returned by teachers currently teaching only courses below the ninth grade level were rejected for use in this study. In cases where a respondent was teaching both junior high school and upper level courses, only the information regarding the upper level courses was used.

A set of fifteen copies of a self-report questionnaire was mailed to each mathematics department chairman of the fifty participating schools. A cover letter was enclosed, explaining the needs and purposes of the study and requesting the chairman to distribute the questionnaires to all the mathematics teachers in his or her school. Each mathematics department chairman was requested to return the completed questionnaires by mail, along with a form containing his or her name and home address. To ensure a good return, each department chairman was informed that he or she would receive a $10.00 check upon return of the completed questionnaires. To ensure confidentiality, teachers were requested not to include their names or the names of their schools in the questionnaires. Although it was necessary to request the department chairmen's names and addresses for the purpose of mailing the $10.00 honorarium, the chairmen were requested not to identify the schools at which they were employed.

Description of Data-Gathering Instrument

A copy of the data-gathering instrument used in this survey is in Appendix A. It is a sixteen-item self-report questionnaire designed to assess teachers' personal use and classroom use of the calculator, and their attitudes toward the use of calculators in mathematics classes.

Items 1 through 5 on the questionnaire were for the purpose of gathering descriptive information. Items 6 and 7 deal with personal use and perceived knowledge of classroom usage of the calculator.

Attitudes toward the use of calculators in the classroom were assessed by Items 8, 9, and 11 on the questionnaire. The purpose of Item 8 was to assess the respondent's general attitude toward the use of calculators in the classroom. The purpose of Item 9 was to test the hypothesis that fewer teachers would favor the use of calculators in courses that deal primarily with basic mathematical skills than in higher level math courses in which students are presumed to have already

mastered these skills. Item 11 consists of eleven statements as to why calculators should or should not be used in the classroom. These items were taken from research conducted by Marilyn N. Suydam (1978). Respondents were asked to indicate their opinions of each of these statements on a Likert-type scale ranging from "strongly agree" to "strongly disagree". The pupose of this item was to determine some specific reasons that teachers might have for favoring or oposing the use of calculators in the classroom.

The purpose of Item 10 was to determine how frequently, and in what situations, teachers actually use calculators in the courses they are currently teaching or have taught most often. Items 12 and 13 deal with teachers' attitudes toward the need for training in effective ways to use calculators in the classroom. The purpose of Item 12 was to determine whether or not teachers are not using calculators in teaching math courses because they do not know how to use them effectively as a teaching aid. The purpose of Item 13 was to determine whether or not teachers would be willing to receive training in the use of calculators as an instructional aid.

Item 15 asks if teachers know of any official policy concerning the use of calculators in their classrooms that exists in the school districts or departments in which they teach. Teachers are asked to describe any such policies of which they are aware. The purpose of this item is to determine whether or not teachers perceive that any such policies exist, either explicitly or implicitly, in their school administrations, and to determine how such policies affect their attitudes toward and their frequency of use of calculators in teaching.

Reliability of Questionnaire

The correlations (see statistical techniques) between the general attitude and personal use questions, and the specific attitude statements are all statistically significant at better than the .05 level. This indicates that the questionnaire is internally consistent. However, further statistical techniques should be applied to test both the validity and reliability of this instrument.

Statistical Techniques

The data obtained from the survey was analyzed using the Statistical

Package for the Social Sciences (SPSS), as implemented by the Computer Center at the University of Pittsburgh. The coding of the data and the computer analysis was done by the author.

After the frequencies were generated, the significance of the distributions, varying from expected (random) frequencies, was determined by using the SPSS subprogram NPAM. This subprogram generates Chi-square and the level of significance. SPSS, as used for this survey, does not take into account any missing data. $p<.05$ was accepted as statistically significant for all Chi-squares.

To test for correlational significance between two variables, the Chi-square statistic for independence was used (subprogram Crosstabs). SPSS uses pair-wise deletion of missing data; hence, the number of cases used for testing significance may be fewer than the number of respondents. As before, the criterion for significance is $p<.05$.

RESULTS

Descriptive Data

Of approximately 500 public high school teachers in Allegheny County, 248 teachers from 49 schools responded. Most of the respondents, 178, were from suburban schools, with 65 teachers responding from city schools and 5 responding from rural schools. More men than women responded, 177 to 69, with 2 respondents failing to indicate their sex on the questionnaire. The largest age group, 130 teachers, was between 31 and 40 years old. There were 53 respondents between the ages of 22 and 30, 37 respondents between the ages of 41 and 49, and 28 respondents of 50 years of age or older. The average number of years of teaching experience was 13.1. Courses taught ranged from General Math to Calculus, and average class size was 24 students. For a more detailed description of the population used in this study see Appendix B, Table I. It appears that the sample surveyed was fairly representative of the population of public high school mathematics teachers, although no techniques were employed to confirm this statistically.

Personal Use and Classroom Knowledge

The first item of this section concerns the teachers' use of calculators outside of the classroom. The frequencies obtained from this item indicate that calculators are used frequently by the mathematics teachers

surveyed. Only 3.3% of the teachers that answered this item stated that they never use a calculator outside of the classroom, while 43.1% answered "seldom" and 53.7% answered "often". The distribution of responses for this item was statistically significant at better than the 0.001 level. (See Appendix B, Table IIA).

The other item from this section asked the respondents to assess their knowledge of calculator usage for the mathematics classroom. Of the 244 teachers that responded to this question, 54.8% assessed their knowledge as "some", and 21.8% assessed their knowledge as "lot". Of the other respondents, 18.0% indicated "little" and 4.1% indicated no knowledge. Again, the distribution of responses was statistically significant at better than the 0.001 level. This indicates that the mathematics teachers surveyed feel they have adequate knowledge of calculators. (See Appendix B, Table IIB).

Attitudes Toward the Use of Calculators in the Mathematics Classroom

The two items which assess the respondents' general attitudes toward the use of calculators in the mathematics classroom indicate that most teachers favor the use of calculators. Of the 242 teachers that responded to the question, "What is your opinion of using calculators in the classroom?", 63.6% of the respondents were either strongly or mildly in favor of using calculators, while only 21.0% were either strongly or mildly opposed. The distribution of responses to this item was statistically significant at better than the 0.001 level. (See Appendix B, Table IIIA).

When responding to the item concerning attitudes toward the calculator as an aid for teaching basic skills, 60.7% of the 239 respondents answered affirmatively. This distribution was statistically significant at the o.001 level. (See Appendix B, Table IIIB).

Item 11 of the questionnaire attempts to determine the respondents' attitudes toward specific reasons for using or not using calculators in the classroom. Surprisingly, the distributions of responses for all eleven sub-items were statistically significant at better than the 0.001 level. (See Appendix B, Table IIIC for complete frequencies and significance). The frequencies for the eleven sub-items indicate that the respondents agreed with the following statements:

Calculators should be used to help in problem solving. (Chi-square=191.6)
Calculators should be used as an aid in computation. (Chi-square=191.1)
Calculators should be used as an aid in exploring, understanding, and learning algorithmic processes. (Chi-square=185.9)
Calculators should not be used because they are a substitute for the development of computational skills. (Chi-square=78.3)

The frequencies of responses indicate that the respondents disagreed with the following statements:

Calculators should not be used because they are faddish. (Chi-square=253.3)
Calculators should not be used because the use of calculators gives a false impression of what mathematics is. (Chi-square=252.3)
Calculators should not be used because of maintenance and security problems. (Chi-square=222.5)
Calculators should not be used because they are not available to all students. (Chi-square=131.0)
Calculators should be used because they improve behavior. (Chi-square=104.5)
Calculators should be used to lessen the need for memorization. (Chi-square=87.1)
Calculators should be used because they are so available. (Chi-square=45.0)

Attitudes Toward Teacher Training and Materials

Of the 227 teachers that responded to Item 12, 63.9% answered that they do not feel that adequate materials on calculator usage are available to them. This distribution of responses is significant at better than the 0.001 level. (See Appendix B, Table IVA).

When asked if they would attend a workshop dealing with calculator classroom usage (Item 13), only 13.3% of the teachers responding indicated that they would not attend. Of the rest of the teachers responding, 35.4% checked "yes", and 51.3% checked "maybe". Again, the significance of this distribution was better than 0.001. (See Appendix B, IVB).

Policies

Of the 239 teachers who responded to Item 15, 17.6% indicated that some policy existed within their school administrations regarding the use of calculators in mathematics classes. 64.9% answered "no" to this question, and 17.6% answered "don't know". This distribution of responses is significant at better than the 0.001 level. However, the validity of this item is questionable for several reasons. First of all, the results were not consistent for any one school. Some teachers perceived that some policy existed, while other teachers from the same school stated that no such policy exists. Most of the policies cited were irrelevant to teacher attitudes and frequency of use (e.g.: the policy that teachers must sign for the school's calculators before using them). (See Appendix B, Table V for more detailed information).

Survey of Teacher Practices

For the purposes of this study, there are nine different catagories of math courses: general math (i.e.: basic skills); applied, business, or consumer math; Algebra I; Algebra II; Algebra unspecified; Geometry (all levels); Trigonometry; Calculus; and other. The data concerning teacher practices of allowing and/or encouraging students to use calculators were analyzed according to the catagory of subject matter in which each course fell. Two of the course catagories must be viewed differently. Nine of the teachers responding did not indicate what level of Algebra they taught. Since this is such an insignificant response, and since Algebra II is considered to be on a significantly higher level than Algebra I, no conclusions should be made. The "other" catagory is the catch-all catagory. Thirty-six of the courses listed by the respondents either did not fit any of the usual catagories of math (e.g.: statistics, "advanced Math", special topics), or the titles of the courses did not convey the essence of the content to someone who is not familiar with that school's math program. Computer science courses were also placed in this catagory. None of the courses included in this catagory were numerous enough to be significant on their own. Since this catagory includes so many different courses, the results must be viewed with caution. For the purposes of this study, Algebra II, Geometry, Trigonometry, Calculus, and "other" are considered to be higher level math courses.

The respondents were asked to answer "yes" or "no" to five questions concerning calculator practices for up to three courses that they currently teach, or have taught, most often. The questions concern the teacher practices of forbidding the use of calculators by their students, allowing/encouraging the use of calculators for homework, allowing/encouraging the use of calculators in the classroom, allowing/encouraging the use of calculators for tests, and teaching the students how to use a calculator. The exact questions, the frequencies of responses for each course, and the significance of the responses are given in Appendix D, Table VI.

As might be expected, calculators were used more often in higher level math courses than in the other courses. Comparison of the five higher level courses with the General Math, Applied Math, and Algebra I catagories show that in all cases:

Students in higher level courses were forbidden to use calculators less often.
Students in higher level courses were allowed/encouraged to use calculators for homework more often.
Students in higher level courses were allowed/encouraged to use calculators in class more often.
Students in higher level courses were allowed/encouraged to use calculators for tests more often.

The results of this survey indicate that, for the most part, teachers do not forbid the use of calculators. Except for the Applied Math and the Algebra unspecified catagories, the distributions of responses were statistically significant at, or better than, the 0.005 level for not forbidding the use of calculators. The responses for Applied Math and Algebra unspecified indicate that calculators are not forbidden, but the distributions for these catagories were not statistically significant.

For the question concerning the use of calculators for homework the results indicate that teachers allow the use of calculators for homework. As stated previously, this is particularly true for the higher level courses. For all five of the higher level catagories the distributions of responses were significant at, or better than, the 0.005 level. For Algebra I, the significance of the distribution was 0.024 for allowing the use of calculators for homework. The distributions for General Math, Applied Math, and Algebra unspecified were not significant.

As stated before, the teachers of the higher level math courses allow the use of calculators in class. These are the only catagories in which the distributions of responses are statistically significant. In all five catagories the use of calculators in class was favored with a significance of better than 0.005.

None of the courses significantly favored the use of calculators for tests. In fact, the only statistically significant ($p < .05$) distributions were against the use of calculators for tests. These distributions were in the General Math, Applied Math, Algebra I, and Geometry catagories. This was the only instance in teacher practices in which distributions of responses occurred which significantly disfavored the use of calculators. The Trigonometry and Calculus catagories had more responses in favor of the use of calculators for tests than against this practice, but the distributions were not statistically significant.

The Trigonometry catagory was the only catagory where a majority of the teachers taught the use of calculators. However, the distribution

of responses was not statistically significant. The Algebra I, Algebra II, and Geometry catagories had statistically significant ($p < 0.001$) distributions which indicate that the use of calculators is not taught. The other catagories did not have significant distributions of responses.

It is interesting to not that Applied Math was the only catagory that did not have a significant distribution of responses favoring the use of calculators for any of the five statements. As might be expected, the Trigonometry catagory was the only catagory in which the use of calculators was favored for all the given situations. However, only three of the five distributions were statistically significant.

Correlation of Attitudes, Practices, and Descriptive Data

This section is included primarily as a catalyst for further research. The correlational data reported here is preliminary and incomplete. Therefore, the results are merely summarized, with no figures given.

The correlational results indicate that there are not statistically significant correlations between teachers' attitudes and any of the descriptive data. As expected, there appears to be some statistically significant correlations between teachers' attitudes toward the classroom use of calculators and their actual use of calculators in the classroom. This is particularly true for the Algebra II, Trigonometry, and "other" catagories. There are no negative correlations between attitudes and practices. There are no statistically significant correlations between attitudes and teacher practices concerning the teaching of the use of calculators.

CONCLUSIONS

The results of this study indicate that there is a need for the development of instructional materials and teacher training programs in the use of calculators in mathematics instruction. This is shown be teachers' attitudes and practices concerning the use of calculators in their classrooms, and by the lack of clear-cut administrative policies regarding calculator use in mathematics instruction.

It appears that there is some reluctance to use calculators in the classroom due to the fear that students who have not yet learned basic computational skills will never learn these skills if they are provided with electronic calculators to do the computations for them. Many of

the teachers who responded to the "additional comments" section of the questionnaire expressed this fear, which was further confirmed by the responses to other items on the questionnaire. (See Appendix C). Even though teachers generally favored the use of calculators in the classroom, and favored their use as an aid in computation and in teaching basic skills, they also tended to believe that calculators should not be used because they are a substitute for developing computational skills. Teachers were also more likely to allow and/or encourage students in higher level math courses, where students are presumed to have already mastered basic skills, to use calculators in their course work. Thus, although teachers believe that calculators can be an aid in teaching basic skills, they are forbidding their lower-level students to use them, and very few teachers are teaching their students to use calculators. This leads to the conclusion that teachers are in need of some instructional materials and training to enable them to use calculators in their basic skills classes in such a way that the calculator can be an effective aid to learning rather than a crutch that prevents the development of computational skills.

It is rather surprising that the use of calculators in Applied Math and Business Math courses is so minimal. These courses are designed to enable students to function effectively in the world of business and in handling their own personal finances. In the past few years, the advent of the hand-held, electronic calculator has greatly influenced both these areas. Thus, the failure to teach the use of the calculator in this type of math course represents a failure in curriculum design in keeping up with modern technology, and instructional materials and teacher training in this area are badly needed.

Very few respondents stated that official policies concerning the use of calculators in math instruction exist within their school administrations. Those who did cite such policies usually were inconsistent with other respondents who are teaching in the same schools. This makes it evident that school districts represented in this study have not developed clear-cut, consistent policies regarding this issue. One possible interpretation of this is that administrators do not wish to take a definite stand on such a controversial issue, and are leaving decisions in this matter up to the discretion of the individual teacher until they receive further information regarding public opinion and the effectiveness of the calculator as a teaching aid. Another possibility is that curriculum

planners within the school districts and math departments have overlooked the instructional possibilities of the calculator in designing modern mathematics programs. In either case, well-designed instructional materials and teacher training programs in the use of the calculator as an instructional aid would help administrators in each school district to develop effective, clear-cut, consistent policies regarding the place for the calculator in their school mathematics programs.

RECOMMENDATIONS

A questionnaire to be used in the replication of this survey should be more comprehensive and more specific. Further research should be conducted to determine whether or not teachers feel that a separate course in the use of calculators should be offered to students, and to determine in which courses teachers feel that calculators should be used. On the questionnaire used in the present study, the statements regarding allowing/encouraging the use of calculators were probably too ambiguous. Allowing the use of calculators in classes, in doing homework, and in taking tests is quite different from encouraging the use of calculators in these situations, and there should be a sharper differentiation between these two practices in further research. Further research should also be conducted to determine more specific situations in which teachers feel that calculators should or should not be used.

One of the limitations of this study is the lack of statistical information regarding the validity and reliability of the data-gathering instrument and the representativeness of the sample used. Although the questionnaire appears to be internally consistent, its validity and reliability are still in question. The development of a nationally standardized questionnaire would solve this problem, and would facilitate research to determine whether or not geographical differences affect attitudes and practices concerning the use of calculators in math instruction. A randomly selected sample of high school mathematics teachers from the entire country would provide a more conclusive survey of the population of high school mathematics teachers, than does surveying all the high school math teachers in one specific geographical area, as was done in this study.

Other suggestions for further research include sampling the population of school mathematics department chairmen and district curriculum planners

to determine if adequate instructional materials on the use of calculators are currently available to teachers. The present study included only public high schools; a survey of teachers in private school, which usually have different budgetary restraints than public schools, might be valuable in determining whether or not attitudes of teachers and administrators are affected by financial constraints in making calculators available to students. Public opinion surveys are essential to keeping school administrators and teachers informed of parents' attitudes toward the use of calculators in mathematics education, and determining whether or not there is a need for public education regarding the merits and limitations of allowing and/or encouraging students to use calculators at home and at school.

As stated previously, there is a great need for well-researched instructional materials on ways in which teachers can effectively use calculators as instructional aids, and ways in which curriculum planners can effectively incorporate the use of calculators into mathematics education.

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APPENDIX A

Questionnaire

Cover Letter . .

University of Pittsburgh

SCHOOL OF EDUCATION
Division of Teacher Development

May 10, 1979

Dear Mathematics Department Chairperson:

The use of (mini) calculators in the mathematics classroom has been an active issue in recent years. Hence, we are conducting a survey in Allegheny County to determine the prevailing attitudes and philosophies of mathematics teachers toward using the calculator in the classroom.

Enclosed you will find copies of a calculator information questionnaire. We would appreciate your distributing one copy to each mathematics teacher in your school. Please collect the completed questionnaires, and return them (by June 1) in the two, self-addressed, prepaid envelopes. Thank you for your assistance in this project. Results of this survey will be available upon request.

Sincerely yours,
Martin P. Cohen
Robert F. Fliess
4A32 Forbes Quadrangle
University of Pittsburgh
Pittsburgh, PA 15260
624-1343

FOR YOUR TIME AND EFFORT, TEN DOLLARS WILL BE SENT TO YOU BY COMPLETING THE REQUIRED INFORMATION (cut on the dotted line) AND BY RETURNING IT WITH THE QUESTIONNAIRES.

.....

I, _____ (signature), distributed, collected, and returned the calculator information survey to Dr. Martin Cohen, Mathematics Education, University of Pittsburgh.

Name (please print): _____

Address: _____

_____ Zipcode _____

Social Security Number: _____

PITTSBURGH, PA. 15260

CALCULATOR INFORMATION QUESTIONNAIRE

(1) Type of School: 1. City___ 2. Suburban___ 3. Rural___

(2) Sex: 1. Male___ 2. Female___

(3) Age Group: 1. 22-30___ 2. 31-40___ 3. 41-49___ 4. 50 and over___

(4) Years of teaching experience: _____

(5) Math courses presently taught:

	Course	Average Class Size
	_____	_____
	_____	_____
	_____	_____

(6) How often do you use a calculator outside of the classroom?
1. Never___ 2. Seldom___ 3. Often___

(7) How would you assess your knowledge of calculator usage for your classroom (i.e. for the subject you teach)? 1. None___ 2. Little___ 3. Some___ 4. Lot_

(8) What is your opinion of using calculators in your classroom?
1. Strongly in favor___ 2. Mildly in favor___ 3. Neutral___
4. Mildly opposed___ 5. Strongly opposed___

(9) Do you feel that calculators can be an aide for teaching students basic mathematical skills (e.g. addition, percent, etc.)? 1. Yes___ 2. No___

(10) For the three courses you teach (have taught) most often, please check the appropriate box reflecting your attitude of calculators in the classroom.

	Course_____		Course_____		Course_____	
	Yes	No	Yes	No	Yes	No
Forbid the use of	—	—	—	—	—	—
Allowed/encouraged for homework	—	—	—	—	—	—
Allowed/encouraged in class	—	—	—	—	—	—
Allowed/encouraged for tests	—	—	—	—	—	—
Taught use of	—	—	—	—	—	—

(11) How do you feel about each of the following statements regarding the use of calculators in the mathematics classroom? Please indicate (SA) strongly agree, (A) agree, (N) neutral, (D) disagree, or (SD) strongly disagree for each statement:

Calculators should be used as an aid in computation. ____
Calculators should be used to lessen the need for memorization. ____
Calculators should be used to help in problem solving. ____
Calculators should be used because they improve behavior. ____
Calculators should be used because they are so available. ____
Calculators should be used as an aid in exploring, understanding, and learning algorithmic processes. ____

Calculators should not be used because they are a substitute for the development of computational skills. ____
Calculators should not be used because they are not available to all students. ____
Calculators should not be used because they are faddish. ____
Calculators should not be used because of maintenance and security problems. ____
Calculators should not be used because the use of calculators gives a false impression of what mathematics is. ____

(12) Do you feel that adequate teaching materials on calculator classroom usage are available to you? Yes____ No____

(13) If a one-month, tuition-free, graduate-credit workshop on using calculators in school mathematics were offered during a summer at the University of Pittsburgh, would you like to attend? Yes____ Maybe____ No____

(14) If a one-month, tuition-free, graduate-credit workshop on using computers in school mathematics were offered during a summer at the University of Pittsburgh, would you like to attend? Yes___ Maybe____ No____

(15) Does your district or department have any official policy concerning the use of the calculators in the classroom? Yes___ No____ I don't know____

If yes, what is it?_____

_____

(16) Additional comments:

APPENDIX B

Tables

TABLE I

DESCRIPTIVE INFORMATION

TABLE IA: TYPE OF SCHOOL

Type of School	Absolute Frequency	Relative Percentage
City	65	36.2
Suburban	178	71.8
Rural	5	2.0
Missing	0	0

TABLE IB: SEX

	Absolute Frequency	Relative Percentage	Adjusted Percentage
Male	177	71.4	72.0
Female	69	27.8	28.0
Missing	2	0.8	--

TABLE IC: AGE

Years	Absolute Frequency	Relative Percentage
22-30	53	21.4
31-40	130	52.4
41-49	37	14.9
50+	28	11.3
Missing	0	0

TABLE ID: TEACHING EXPERIENCE

	Absolute Frequency	Relative Percentage	Adjusted Percentage
0-10	94	37.9	38.7
11-20	119	48.0	48.9
21-30	26	10.5	10.7
31-40	4	1.6	1.6
Missing	5	2.0	--

TABLE II

FREQUENCIES AND SIGNIFICANT FOR OUTSIDE USE AND CLASSROOM KNOWLEDGE

TABLE IIA: ITEM 6

How often do you use calculator outside of the classroom?

	Absolute Frequencies	Relative Percentage	Adjusted Percentage
Never	8	3.2	3.3
Seldom	106	42.7	43.1
Often	132	53.2	52.7
Missing	2	0.8	--

Chi-Square	D.F.	Significance
104.293	2	0.001

TABLE IIB: ITEM 7

How would you assess your knowledge of calculator usage for your classroom?

	Absolute Frequencies	Relative Percentage	Adjusted Percentage
None	10	4.0	4.1
Little	44	17.7	18.0
Some	136	54.8	55.7
Lot	54	21.8	22.1
Missing	4	1.6	--

Chi-Square	D.F.	Significance
140.393	3	0.001

TABLE III

TABLE IIIA: ITEM 8

What is your opinion of using calculators in your classroom?

	Absolute Frequency	Percentage	Percentage
Strongly in favor	61	24.6	25.2
Mildly in favor	93	37.5	38.4
Neutral	37	14.9	15.3
Mildly opposed	34	13.7	14.0
Storngly opposed	17	6.9	7.0
Missing	6	2.4	--

Chi-Square	D.F.	Significance
71.719	4	0.001

TABLE IIIB: ITEM 9

Do you feel that calculators can be an aide for teaching students basic mathematical skills?

	Absolute Frequencies	Relative Percentage	Adjusted Percentage
Yes	145	58.5	60.7
No	94	37.9	39.3
Missing	9	3.6	--

Chi-Square	D.F.	Significance
10.883	1	0.001

TABLE IIIC: ITEM 11

RESPONSES TO SPECIFIC STATEMENTS CONCERNING REASONS CALCULATORS SHOULD AND SHOULD NOT BE USED (SEE APPENDIX A FOR COMPLETE STATEMENTS)

	SHOULD STATEMENTS						SHOULD NOT STATEMENTS				
	Aid in Computation	Lessen Memorization	Problem Solving	Improve Behavior	Available	Algorithmic Processes	Substitute Computational	Not Available	Faddish	Maintenance Problems	False Impressions
Respondents Abs. Freq. Adj. %	243 98	244 28.6	243 98	241 97.2	239 96.4	241 97.2	242 97.6	245 98.8	242 97.6	242 97.6	243 98
Strongly Disagree Abs. Freq. Adj. %	10 4.1	79 32.4	6 2.5	63 25.4	38 15.9	5 2.1	20 8.3	11 4.5	96 39.7	46 19.0	45 18.5
Disagree Abs. Freq. Adj. %	25 10.3	86 35.2	21 8.6	89 35.9	76 31.8	20 8.3	78 32.2	102 41.6	120 49.6	135 55.8	144 54.3
Neutral Abs. Freq. Adj. %	22 9.1	30 12.3	33 13.6	20 26.6	55 23.0	39 16.2	21 8.7	47 19.2	18 7.4	14 18.2	31 12.8
Agree Abs. Freq. Adj. %	129 53.1	39 16.0	129 53.1	3 8.1	56 23.4	127 52.7	84 34.7	75 30.6	5 2.1	3 5.8	18 7.4
Strongly Agree Abs. Freq. Adj. %	57 23.5	10 4.1	54 22.2	7 1.2	14 5.9	50 20.7	39 16.1	10 4.1	3 1.2	6 1.2	5 2.1
Chi-Square (4 D.F.)	191.136	87.107	191.630	104.539	45.038	185.867	78.389	131.714	253.331	222.504	252.288
Signif-cance	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

TABLE IV

ATTITUDES TOWARD TEACHER TRAINING AND MATERIALS

TABLE IVA: ITEM 12

Do you feel that adequate teaching materials or calculator usage are available to you?

	Absolute Frequencies	Relative Percentage	Adjusted Percentage
Yes	82	33.1	36.1
No	145	58.5	63.9
Missing	21	8.5	--

Chi-Square	D.F.	Significance
17.485	1	0.001

TABLE IVB: ITEM 13

If a workshop on using calculators in school mathematics were offered would you like to attend?

	Absolute Frequencies	Relative Percentage	Adjusted Percentage
Yes	85	34.3	35.4
Maybe	123	49.6	51.3
No	32	12.9	13.3
Missing	8	3.2	--

Chi-Square	D.F.	Significance
52.225	2	0.001

TABLE V: ITEM 15

Does your district or department have any official policy concerning the use of calculators in the classroom?

	Absolute Frequency	Realtive Percentage	Adjusted Percentage
Yes	42	16.9	17.6
No	155	62.5	64.9
I Don't Know	42	16.9	17.6
Missing	9	3.6	--

Chi-Square	D.F.	Significance
106.854	2	0.001

TABLE VI: ITEM 10

FREQUENCIES AND SIGNIFICANCE OF CALCULATOR USAGE FOR DIFFERENT CATEGORIES OF MATHEMATIC COURSES

Statement		General Math	Applied Math	Algebra I	Algebra II	Algebra Unspecif.	Geometry	Trigo-nometry	Calculus	Other
Forbid Use of Abs. Freq/Adj. %	Yes	20 32.3	9 34.6	19 27.9	5 8.7	3 33.3	8 12.9	4 8.2	1 3.3	6 17.1
	No	42 67.7	17 65.4	49 72.1	52 91.3	6 66.7	54 87.1	45 91.8	29 96.7	29 82.9
	Mis.	- -		3	3	-	1	-	2	1
Chi-Square		7.806	2.462	13.235	38.754	Insuff.	34.129	34.306	26.133	15.114
Significance		0.005	0.117	0.001	0.001	Data	0.001	0.001	0.001	0.001
Allow/encour-age for Homework	Yes	30 50.0	15 62.5	45 63.4	56 93.3	7 77.8	54 85.7	45 91.8	30 100.0	26 76.5
	No	30 50.0	19 37.5	26 36.6	4 6.7	2 22.2	9 14.3	4 8.2	0 0.0	8 23.5
	Mis.	2	2	-	-	-	-	-	2	2
Chi-Square		0.000	1.500	5.085	45.067	I.D.	32.143	34.306	-	9.529
Significance		1.000	0.221	0.024	0.001		0.001	0.001	0.001	0.002
Allow/encour-in Class	Yes	29 50.9	12 52.2	27 42.2	45 77.6	5 62.5	36 65.5	40 83.3	29 90.6	24 66.7
	No	28 49.1	11 47.8	37 57.8	13 22.4	3 37.5	19 34.5	8 16.7	3 9.4	12 33.3
	Mis.	5	3	7	2	1	8	1	-	-
Chi-Square		0.018	0.043	1.563	17.655	I.D.	5.255	21.333	21.125	4.000
Significance		0.895	0.835	0.211	0.001		0.022	0.001	0.001	0.046
Allow/encour-age for Test	Yes	13 23.6	4 17.4	13 21.0	22 39.3	3 33.3	19 34.5	25 54.3	19 63.3	16 44.4
	No	42 76.4	19 82.6	49 79.0	34 60.7	6 66.7	36 65.5	21 45.7	11 36.7	20 55.6
	Mis.	7	3	9	4	-	8	3	2	-
Chi-Square		15.291	9.983	20.903	2.571	I.D.	5.255	0.348	2.133	0.444
Significance		0.001	0.002	0.001	0.109		0.022	0.555	0.144	0.505
Taught Use of	Yes	26 48.1	9 39.1	7 11.7	14 26.9	1 12.5	6 11.8	26 60.5	9 33.3	13 39.4
	No	28 51.9	14 60.9	53 88.3	38 73.1	7 87.5	45 88.2	17 39.5	18 66.7	20 60.6
	Mis.	8	3	11	8	1	12	6	5	3
Chi-Square		0.074	1.087	35.267	11.077	I.D.	29.824	1.884	3.000	1.485
Significance		0.784	0.297	0.001	0.001		0.001	0.170	0.083	0.223

APPENDIX C

Comments

APPENDIX C

This Appendix is a sample of the responses to Item 16 on the questionnaire, which asked for additional comments. The comments printed here are taken from the returned questionnaires in their entirety.

1. Security, maintenance and assignment of school owned calcs is a problem. They are a fact of life, however, and will become more available and more useful. Hence, I am in full favor of their use if introduction of them is made no sooner than 8th grade.

2. Calculators are not used because not all students have access to one. This makes testing difficult. Calculators could ease the manipulative and computative processes of some problems, thus freeing or enlightening the student to seek the more abstract process.

3. Use of calculators depends on the course.

4. At this level I feel calculators are a substitute for learning basic computational skills. I do think a workshop as indicated above is a good idea, to demonstrate the possibilities of a calculator in the classroom.

5. In all math courses the use of a calculator depends on the teacher and the area of instruction and its level.

6. Use of calculators in higher mathematics enables a student to solve complicated problems quickly and is a great reinforcement. Calculators are a subject area that should be covered before college.

7. Calculators do have a place in the educational process as long as they are not replacing memorizing times tables, conversion of percents, etc. I feel they can be used in higher level courses i.e. trig, chem, physics, some calculus. Also they can be used to simplify some basic skills, i.e., balancing checkbooks, etc.